US006533051B1

(12) **United States Patent**
**Singh et al.**

(10) **Patent No.: US 6,533,051 B1**
(45) **Date of Patent: Mar. 18, 2003**

(54) **ROLLER CONE DRILL BIT SHALE DIVERTER**

(75) Inventors: **Amardeep Singh**, Houston, TX (US); **Dennis Cisneros**, Kingwood, TX (US); **Sujian J. Huang**, The Woodlands, TX (US); **Quan V. Nguyen**, Houston, TX (US)

(73) Assignee: **Smith International, Inc.**, Houston, TX (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/390,717**

(22) Filed: **Sep. 7, 1999**

(51) **Int. Cl.**[7] ..... **E21B 10/22**
(52) **U.S. Cl.** ..... **175/371**; 175/365
(58) **Field of Search** ..... 175/331, 365, 175/371, 372

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | | |
|---|---|---|---|---|---|
| 4,431,066 | A | | 2/1984 | Cunningham et al. | 175/372 |
| 4,822,057 | A | * | 4/1989 | Chia et al. | 277/84 |
| 5,056,610 | A | | 10/1991 | Oliver et al. | 175/371 |
| 5,358,061 | A | | 10/1994 | Van Nguyen | 175/371 |
| 5,570,750 | A | * | 11/1996 | Williams | 175/371 |
| 5,740,871 | A | * | 4/1998 | Williams | 175/371 |
| 6,026,917 | A | * | 2/2000 | Zahradnik et al. | 175/371 |
| 6,033,117 | A | * | 3/2000 | Cariveau et al. | 384/94 |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| GB | 338146 | 6/1929 |
| GB | 352240 | 6/1930 |
| GB | 444712 | 9/1934 |
| GB | 457403 | 8/1935 |
| GB | 2 283 037 A | 4/1995 |
| WO | WO 80/00265 A1 | 2/1980 |

OTHER PUBLICATIONS

Hughes Christensen brochure (a Baker Hughes company) entitled "Ultra Max High Performance Bits for Motor and High Speed Applications", dated 1998.
Great Britain Search Report, dated Dec. 12, 2002, 2 pages.
PCT International Search Report, Oct. 20, 2000, 2 pages.

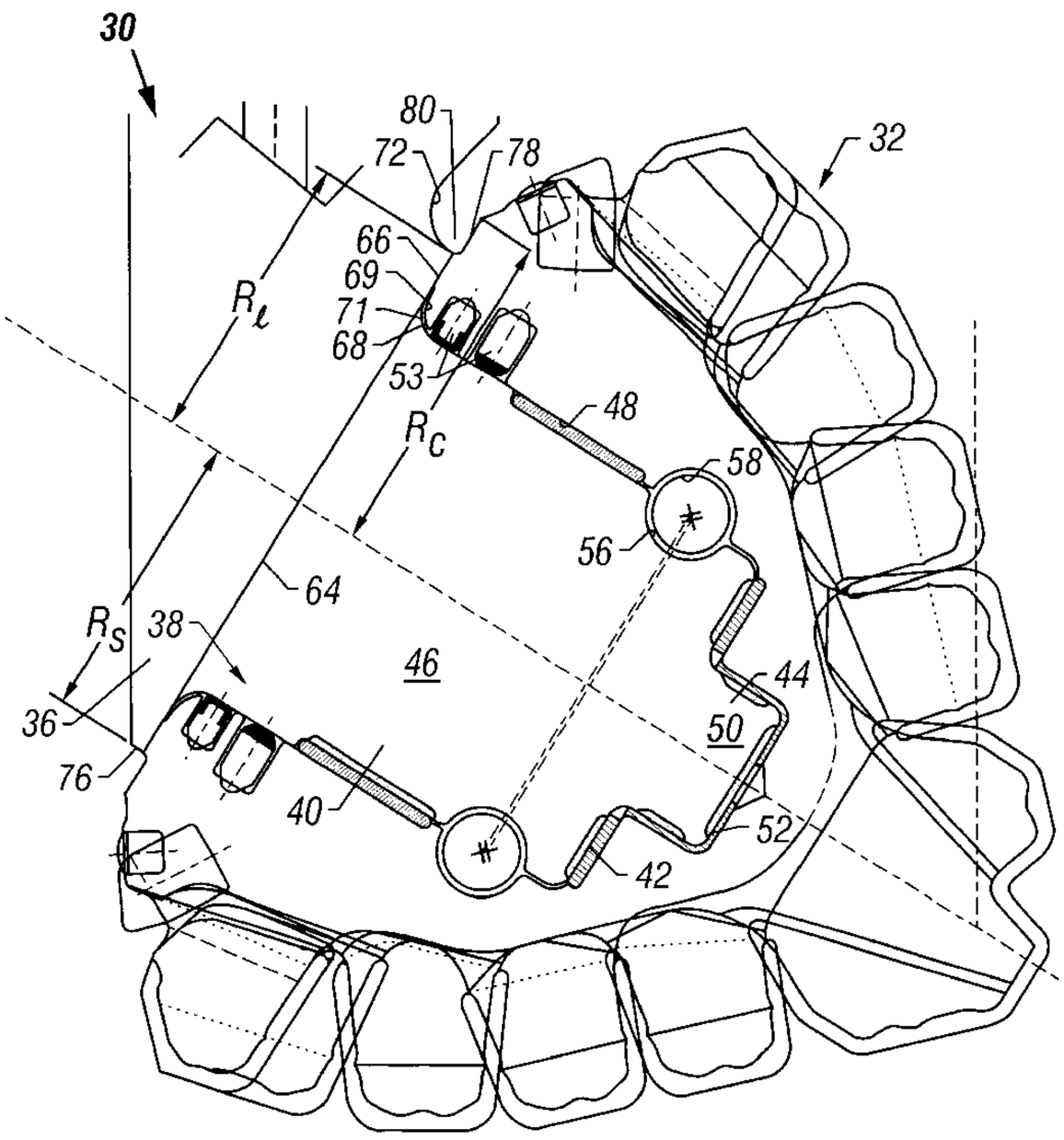
* cited by examiner

*Primary Examiner*—David Bagnell
*Assistant Examiner*—Jennifer H Gay
(74) *Attorney, Agent, or Firm*—Rosenthal & Osha L.L.P.

(57) **ABSTRACT**

A roller cone drill bit includes a bit body adapted to be rotated about a longitudinal axis. At least one leg which terminates in a shirttail portion depends from the bit body. The shirttail portion defines a first end face having a first circumferential groove thereon. The first circumferential groove has a radius equal to the radius of a tip of the shirttail portion. A journal is cantilevered from the leg, and a roller cone is rotatably mounted on the journal. The roller cone has a second end face adjacent to the first end face. A second circumferential groove is formed on the second end face.

**6 Claims, 9 Drawing Sheets**



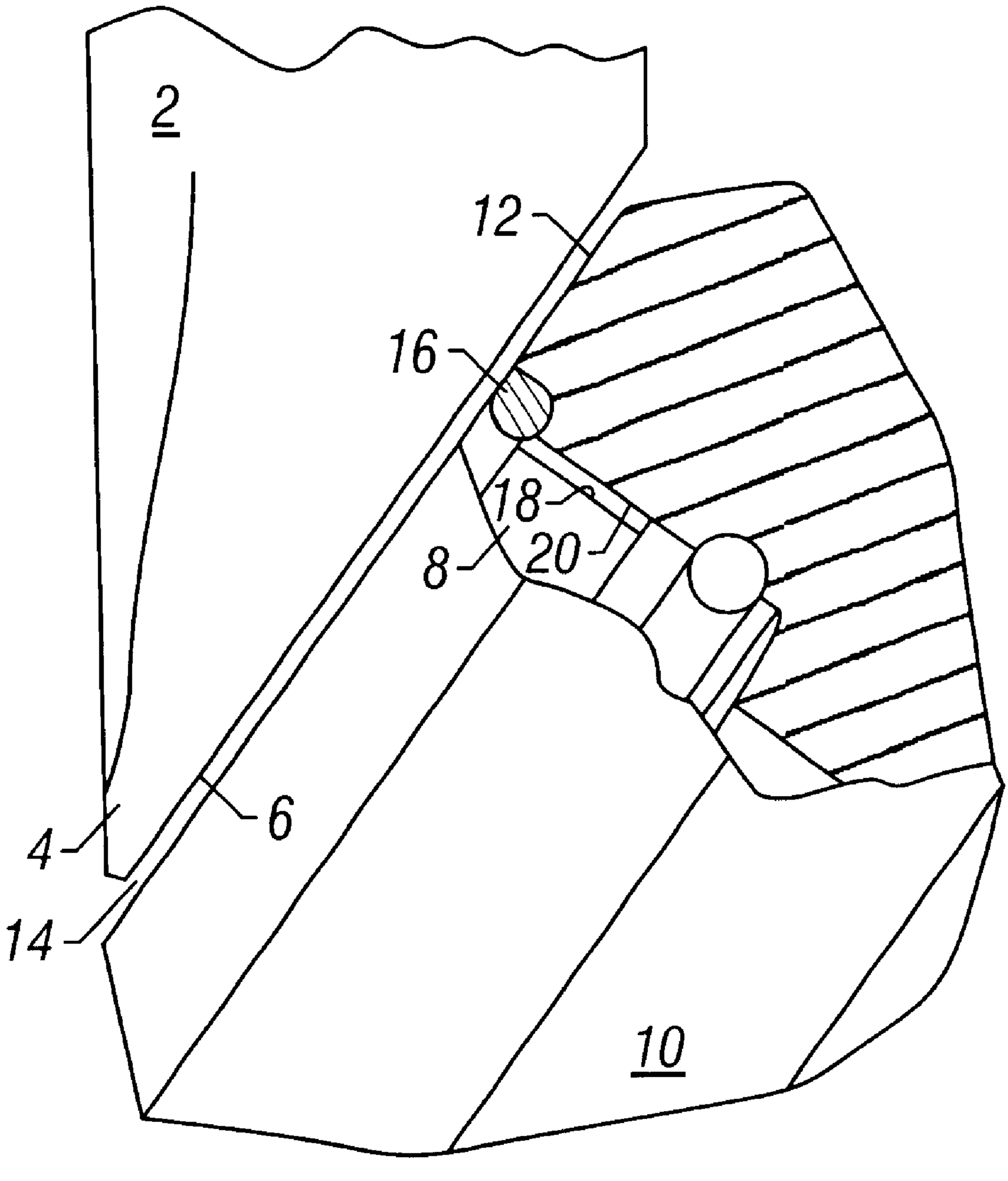



*FIG. 1*
*(Prior Art)*

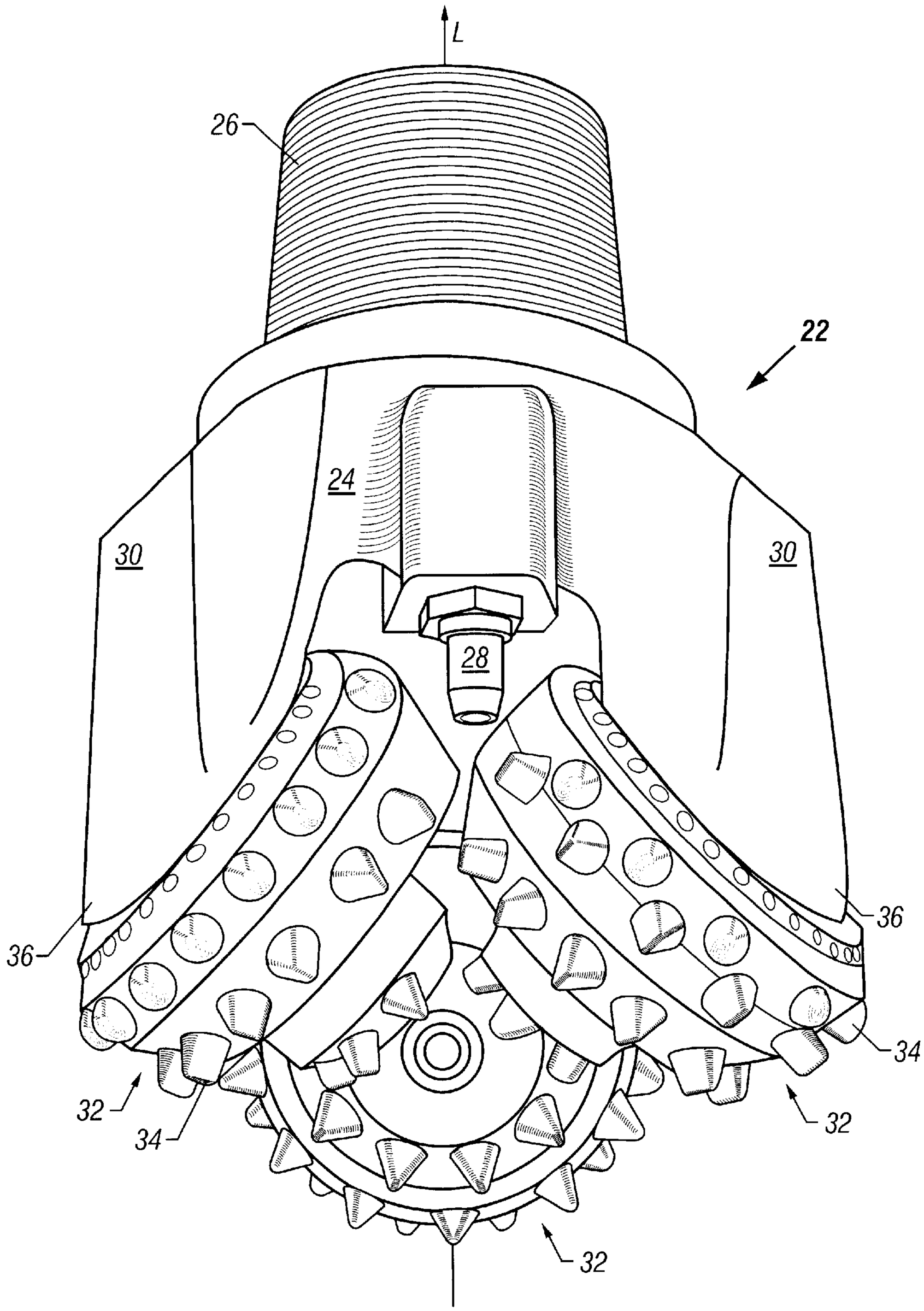



FIG. 2

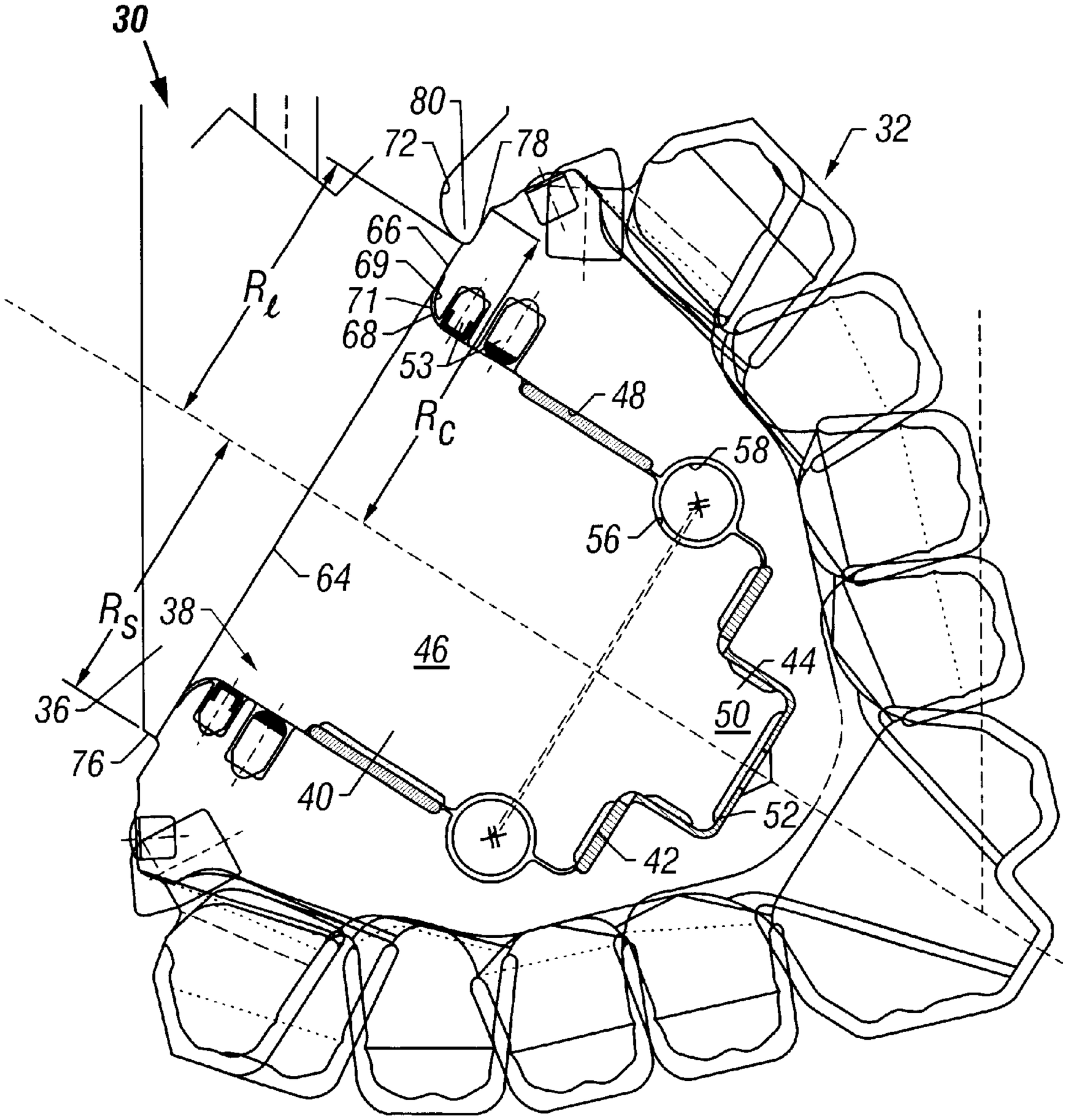

30
80
72
78
32
66
69
71
68
53
48
58
56
64
38
46
44
50
52
42
40
76
36
$R_\ell$
$R_c$
$R_s$

FIG. 3

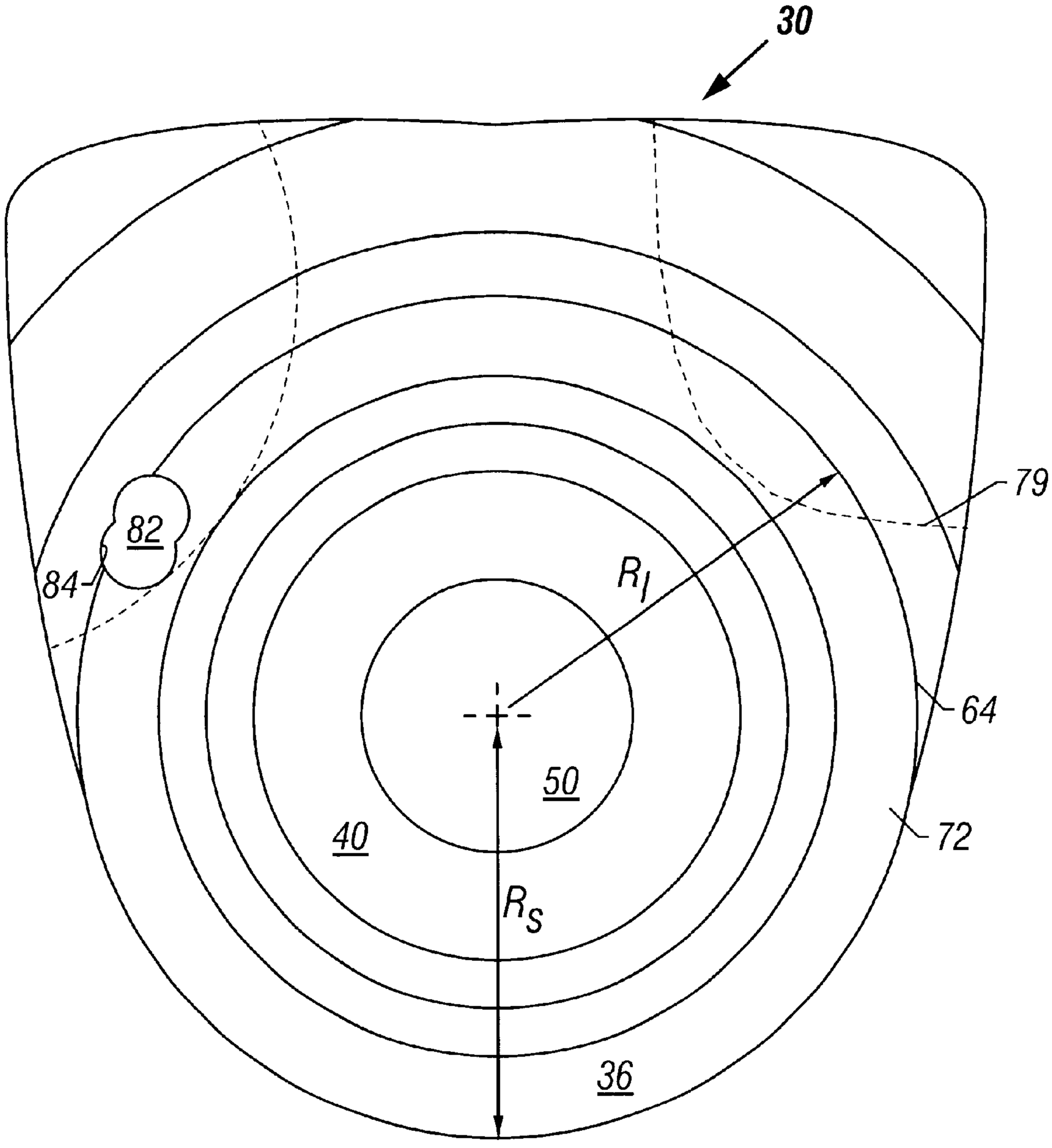



FIG. 4

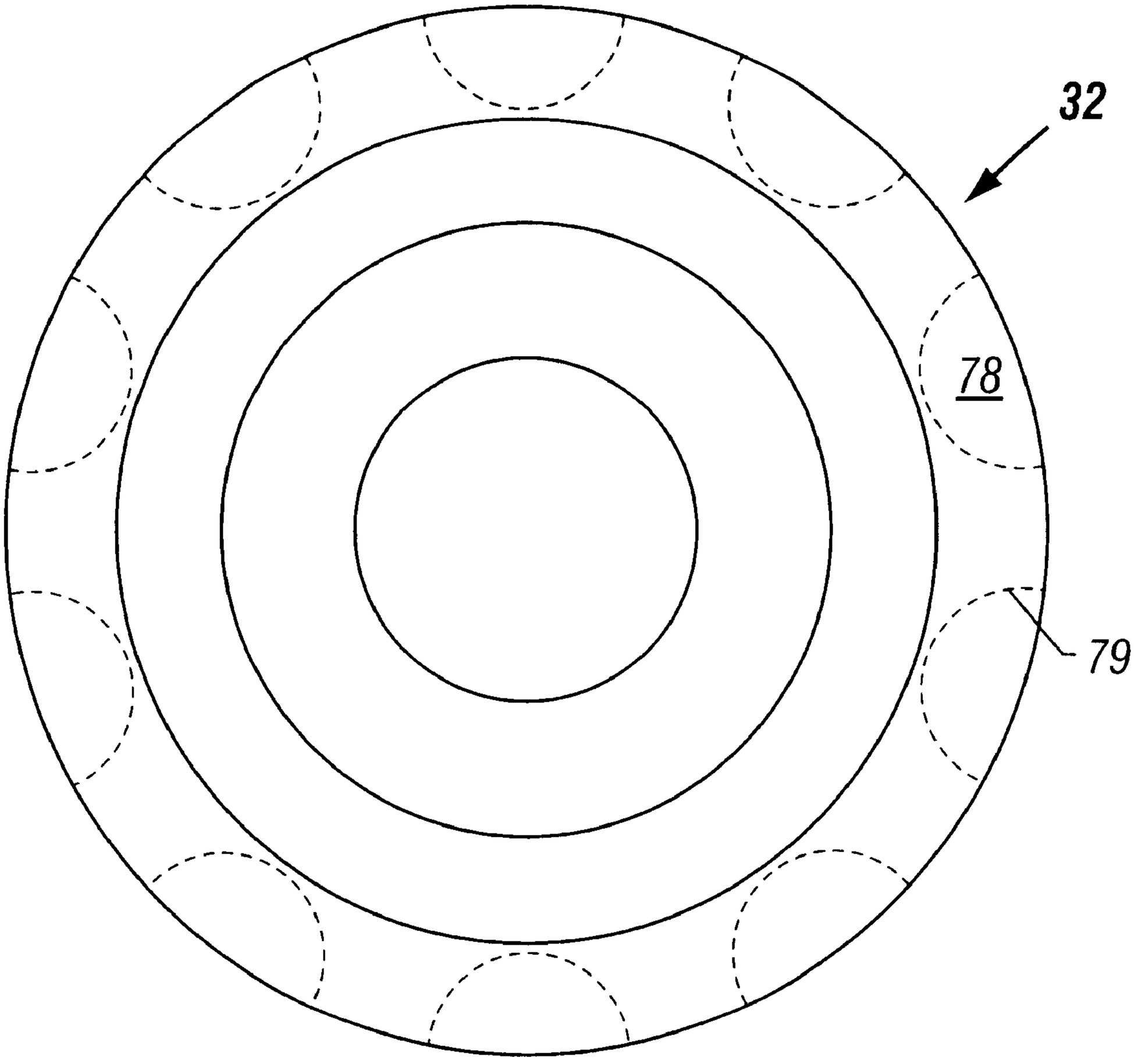



FIG. 5

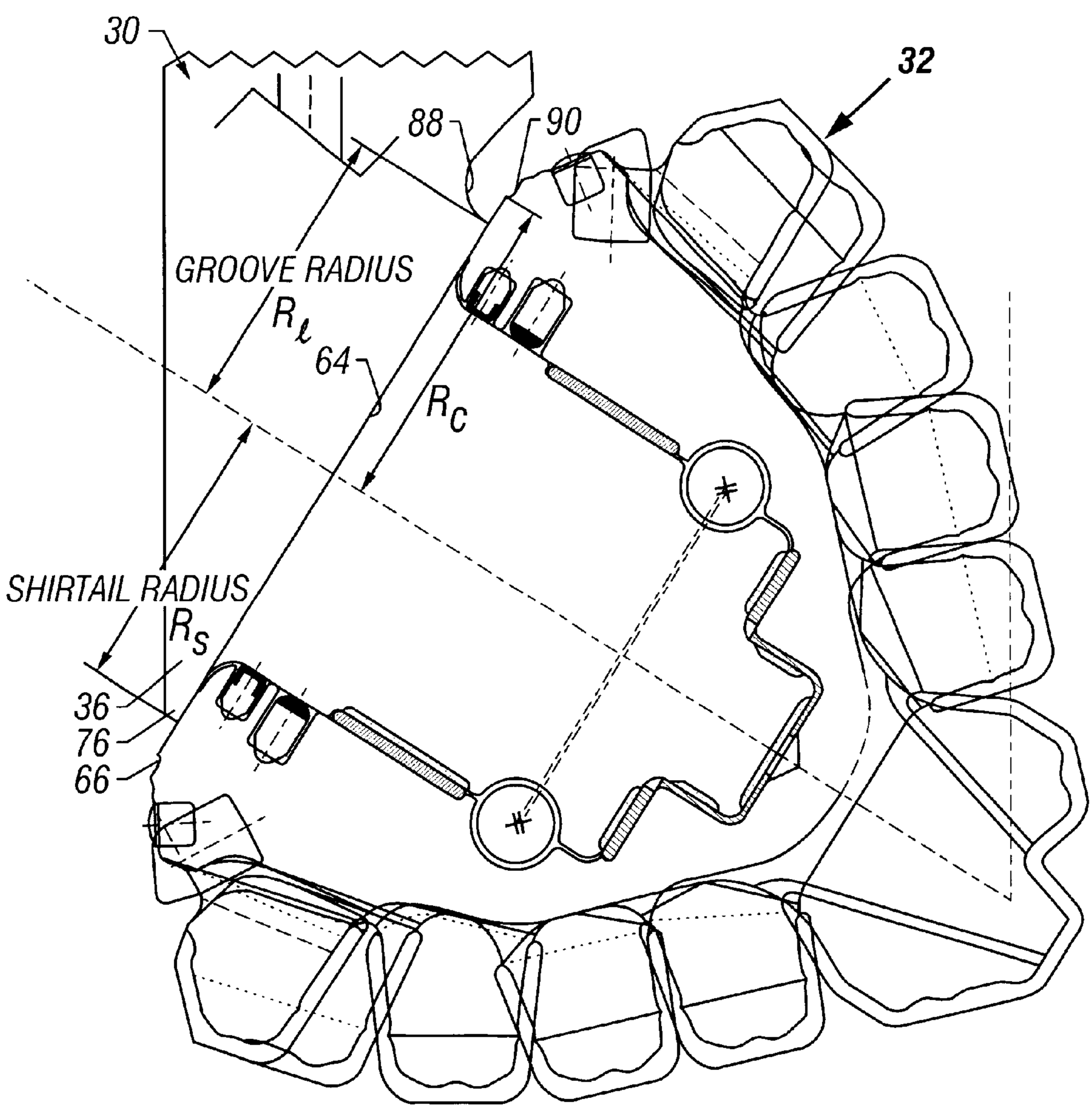

30
88
90
32
GROOVE RADIUS
$R_\ell$
64
$R_C$
SHIRTAIL RADIUS
$R_S$
36
76
66

FIG. 6A

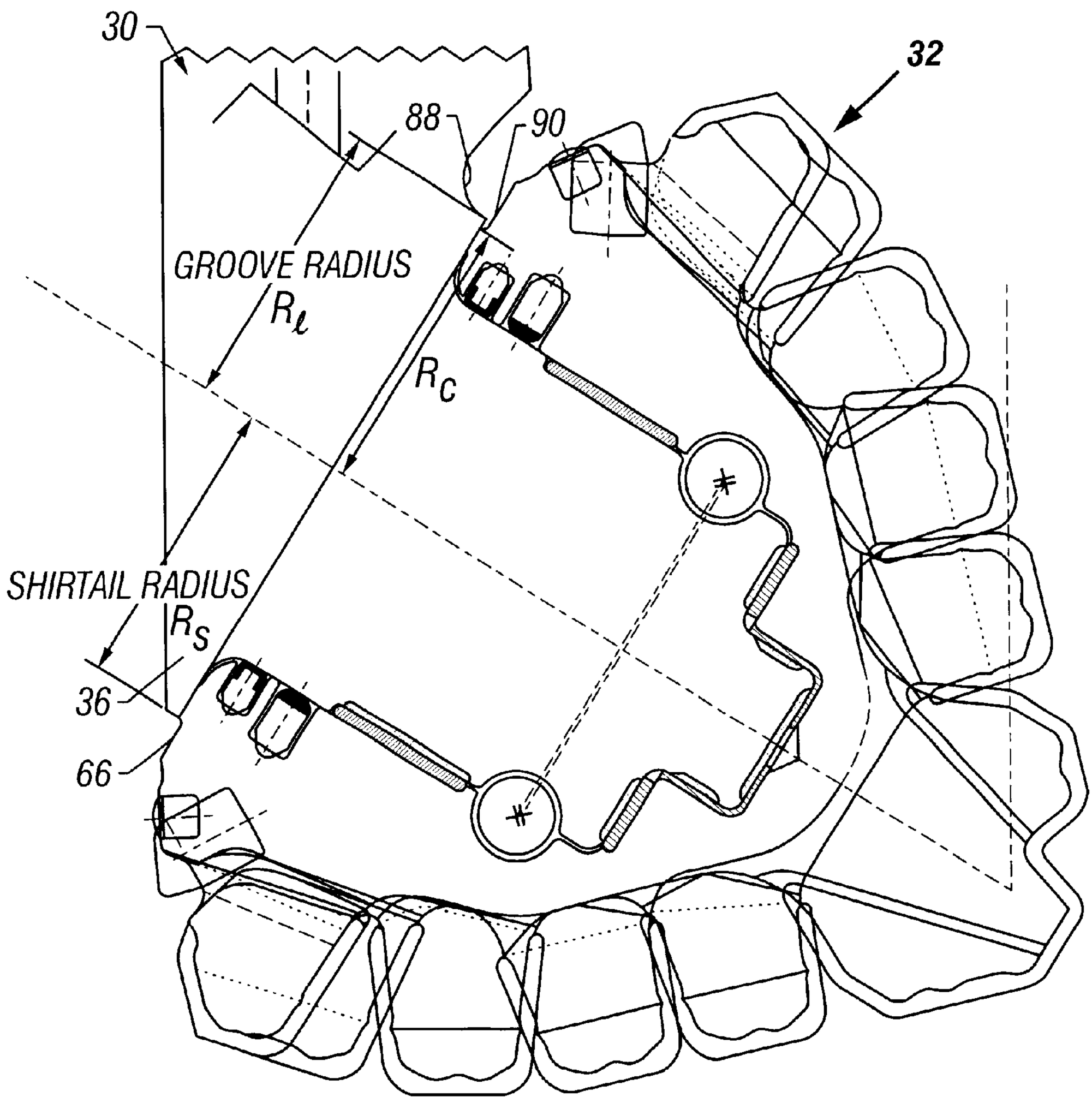



FIG. 6B

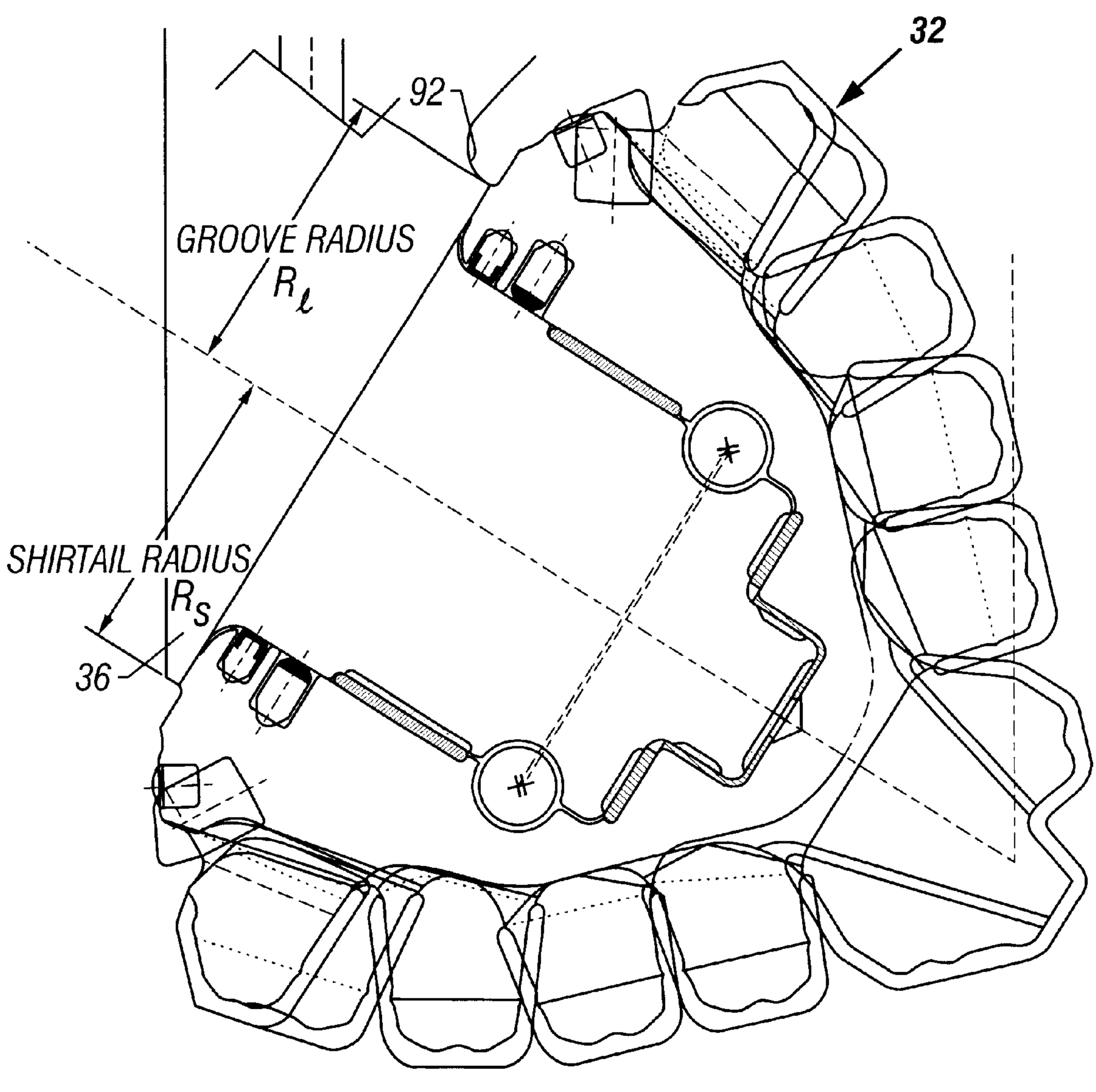



FIG. 7A

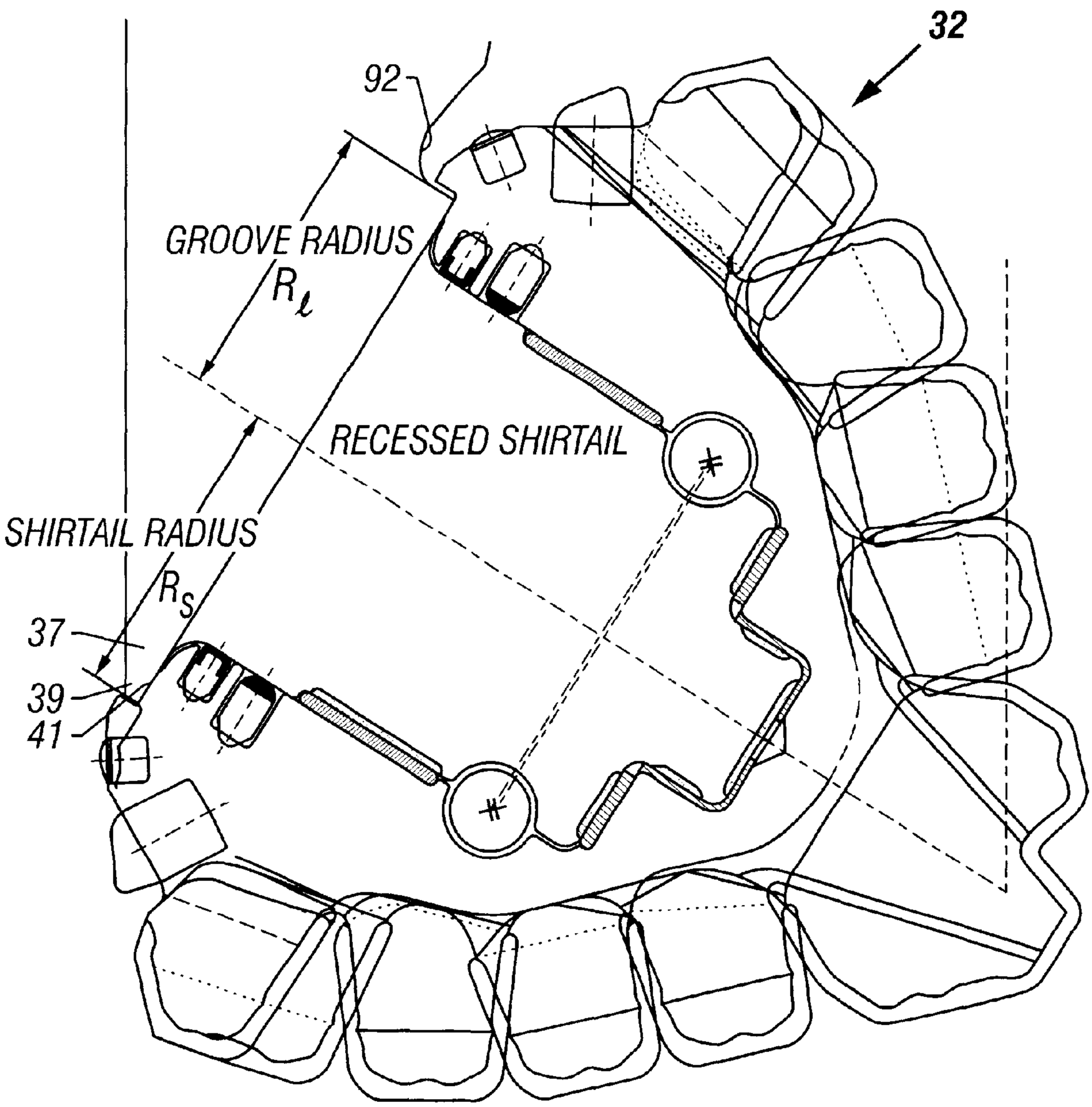

32
92
GROOVE RADIUS
$R_\ell$
RECESSED SHIRTAIL
SHIRTAIL RADIUS
$R_S$
37
39
41

FIG. 7B

# ROLLER CONE DRILL BIT SHALE DIVERTER

## BACKGROUND OF THE INVENTION

1. Technical Field

The invention relates generally to roller cone drill bits. More particularly, the invention relates to a means for diverting shale or other debris from the drill bit during operation.

2. Background Art

Roller cone drill bits typically include a main body with a threaded pin formed on the upper end of the main body for connecting to a drill string, and one or more legs depending from the lower end of the main body. FIG. **1** shows an example of a drill bit leg **2** which terminates in a "shirttail" portion **4**. A journal **8** is cantilevered from an end face **6** of the leg **2**. The journal **8** rotatably supports a roller cone **10**. When the roller cone **10** is mounted on the journal **8**, the end face **12** of the roller cone **8** is adjacent to the end face **6** of the leg **2**. In some types of roller cone bits, a clearance **14** may be provided between the end faces **6** and **12** to prevent interference between the leg **2** and the roller cone **8** during operation of the drill bit. If provided in a particular bit, the clearance **14** is normally held to fairly close tolerance to help limit axial movement of the roller cone **10** on the journal **8**. A seal **16** may be provided to retain lubricant between the mating surfaces **18** and **20** of the journal **8** and the roller cone **10**, respectively, and to protect the lubricant from contaminants.

The main body of the drill bit has an internal chamber and a plurality of nozzles through which fluid received in the internal chamber is directed to the exterior of the main body. Ideally, the fluid flowing out of the nozzles would flush all debris away from the drill bit as the drill bit cuts the earth formation. However, debris tends to accumulate in the clearance between the adjacent end faces of the leg and the roller cone. Accumulation of debris in the clearance between the adjacent end faces of the leg and the roller cone is undesirable for at least two reasons. First, the relative motion between the roller cone and the leg can cause the accumulated debris to abrade the end faces of the leg and the roller cone. The end face of the leg is in a vulnerable section of the leg, i.e., the juncture between the leg and the journal. As a result, abrasion of the end face of the leg weakens the leg. Secondly, the accumulated debris can damage the seal which is intended to protect the mating surfaces of the journal and the roller cone from debris and other contaminants.

Solutions to the problem of debris accumulation in the clearance between the end faces of the leg and the roller cone are not new. U.S. Pat. No. 5,056,610 to Oliver et al, for example, discloses a solution to the debris accumulation problem which includes providing a "burn plug" which has a debris diverting ridge formed in its face. The burn plug is secured in an aperture in the end face of the leg and oriented such that the diverting ridge deflects debris away from the clearance between the end faces of the leg and the roller cone. The burn plug is energized to urge its ridged face against the end face of the roller cone. U.S. Pat. No. 5,358,061 to Van Nguyen discloses a different solution to the debris accumulation problem, which includes providing a hard metal scraper pad to wipe debris off the end face of the roller cone. The hard metal scraper pad is mounted across a trailing end of a circumferential groove on the end face of the leg. In another debris diverter system, a combination of



a mud wiper on the end face of the leg which cooperates with a groove in the end face of the roller cone is used to control accumulation of debris in the clearance between the end faces of the leg and the roller cone.

## SUMMARY OF THE INVENTION

One aspect of the invention is a roller cone drill bit which comprises a bit body that is adapted to be rotated about a longitudinal axis. The bit body has at least one leg depending therefrom. The leg terminates in a shirttail portion. The shirttail portion defines a first end face. A first circumferential groove formed on the first end face has a radius equal to the radius of a tip of the shirttail portion. A journal is cantilevered from the leg. A roller cone is rotatably mounted on the journal. The roller cone has a second end face adjacent to the first end face. A second circumferential groove is formed on the second end face. The second circumferential groove has a radius which matches the radii of the shirttail tip and the first circumferential groove.

Another aspect of the invention is a roller cone drill bit including a bit body adapted to be rotated about a longitudinal axis. The bit body has at least one leg depending from it. The leg terminates in a shirttail portion. The shirttail portion defines a first end face, this first end face having a first circumferential groove defined thereon. The first circumferential groove has a radius which is smaller than a radius of a tip of the shirttail portion. The leg also includes a journal cantilevered from it. A roller cone is rotatably mounted on the journal. The roller cone has a second end face adjacent to the first end face. In one example of this aspect of the invention, the roller cone includes a second circumferential groove on the second end face.

Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross section of a prior art drill bit leg.

FIG. **2** shows a perspective view of a drill bit.

FIG. **3** is a cross section of one of the legs of the drill bit shown in FIG. **2**.

FIG. **4** shows an end view of the leg shown in FIG. **3**.

FIG. **5** shows an end view of the roller cone shown in FIG. **3**.

FIGS. **6A–7B** show other embodiments of the drill bit leg and the roller cone.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **2** shows a roller cone drill bit **22** which comprises a bit body **24** that is adapted to rotate about a longitudinal axis L. The upper end of the bit body **24** includes a threaded pin **26** which can be coupled to another tool, usually a drill string (not shown) to turn the bit **22** to drill earth formations (not shown). Nozzles **28** are provided on the bit body **24** to direct fluid ("drilling mud") received in an internal chamber (not shown) in the bit body **24** to the exterior of the bit body **24**. Three legs **30** extend downwardly from the bit body **24**. The legs **30** in the bit shown in FIG. **2** are spaced 120 degrees apart along the circumference of the bit body **24**. A roller cone **32** is rotatably coupled to each leg **30**. The roller cones **32** have cutting elements **34** which cut earth formation as the drill bit **22** is rotated about the longitudinal axis L. Although the drill bit **22** is shown as having three legs **30**, it should be clear that the invention is equally applicable to a drill bit

having only one leg or any other suitable number of legs. Also, the invention is independent of the type of cutting elements on the roller cones **32**.

Each leg **30** terminates in a substantially circularly-shaped "shirttail" portion **36**. FIG. **3** shows the shirttail portion **36** with a bearing pin **38** cantilevered from an end face **64** of the leg **30**. The bearing pin **38** includes a journal **40**, an axial thrust face **42**, and a nose pin **44**. The journal **40** forms a main bearing surface **46** for the roller cone **32**. The roller cone **32** has a bearing surface **48** which provides a bearing for the main bearing surface **46**. The nose pin **44** forms a bearing surface **50** which is retained within a complementary surface **52** within the roller cone **32**. Lubricant is fed between the bearing surfaces **46** and **48** through one or more lubrication ports (not shown) in the journal **40** to minimize friction between the bearing surfaces. Friction between the bearing surfaces **46** and **48** may also be minimized by placing a low-friction bearing material, roller bearing, ball bearing, or other anti-friction bearing between the bearing surfaces. Seals **53** are provided to retain the lubricant between the bearing surfaces **46** and **48**. However, it should be clear that the invention is not limited to sealed bearing drill bits.

The roller cone **32** is retained on the journal **40** by a ball lock system which includes cone retention balls **54** between ball races **56** and **58** on the bearing surfaces **46** and **48** of the journal **40** and the roller cone **32**. The cone retention balls **54** are fed between the ball races **56** and **58** through a ball hole (not shown) that runs from the shirttail portion **36** to the journal **40** and terminates at the ball race **56**. The cone retention balls **54** are retained between the ball races **56** and **58** by welding a plug (not shown) in the shirttail side of the ball hole. Other methods of retaining a roller cone on a journal, e.g., segmented cone retention rings disposed in a slot on the journal and subsequently threadedly locked to the roller cone, can also be used with the invention.

When the roller cone **32** is mounted on the journal **40**, the end face **66** of the roller cone **32** is adjacent to and generally parallel to the end face **64** of the leg **30**. In this example, a clearance **68** is defined between the roller cone **32** and the throat **70** of the leg **30**, i.e., the juncture between the leg **30** and the journal **40**, to prevent interference between the roller cone **32** and the leg **30** during operation of the drill bit **22**. The clearance **68** is defined between two generally parallel surfaces **69** and **71**. A substantially circularly-shaped circumferential groove **72** is formed in the end face **64** of the leg **30**. The radius $R_l$ of the groove **72** in this example matches the radius $R_s$ of the tip **76** of the shirttail portion **36**. A circumferential groove **78** is formed in the end face **66** of the roller cone **32**. The radius $R_c$ of the groove **78** on the roller cone **32** in this example matches the radius $R_l$ of the groove **72** on the leg **30**. The radii $R_l$, $R_c$, and $R_s$ are measured from the rotational axis R of the roller cone **32**.

FIGS. **4** and **5** show end views of the leg **30** and the roller cone **32**, respectively. As shown, and as previously explained, the circumferential grooves **72** and **78** on the leg **30** and on the roller cone **32**, respectively, each have a substantially circular profile. However, it should be clear that the circumferential grooves **72** and **78** may also be made of a series of shaped cuts, for example shaped cuts **79**, arranged in a substantially circular pattern. It should also be understood that the shirttail portion **36** need not be precisely circular but may instead be formed from a series of flat or other shaped surfaces which in the aggregate approximate a circular profile having the approximate radius $R_s$.

Referring to FIG. **3**, the circumferential grooves **72** and **78** form a passage **80** which runs through 360 degrees along the end faces **64** and **66**. The passage **80** formed by the matching circumferential grooves **72** and **78** provides a clean path for debris to circulate around the throat **70** during operation of the drill bit, thus eliminating or substantially reducing erosion of the throat **70**. Referring to FIG. **4**, a burn plug **82** is mounted in an aperture **84** in the end face **64** of the leg **30** to deflect debris away from the clearance **68** (shown in FIG. **3**). The burn plug **82** may be completely embedded in the end face **64** or may be flush with the end face **64** or project from the end face **64**. Additional burn plugs may be mounted in apertures in the end face **64** of the leg **30**, if desired. It should, however, be clear that the invention can be practiced without a burn plug.

The invention is not limited to circumferential grooves of matching radii on adjacent end faces of the leg and the roller cone. FIGS. **6A–7B** show other arrangements of grooves that will result in reduction of the erosion of the throat.

In FIG. **6A**, the circumferential grooves **88** and **90** on the end faces **64** and **66** of the leg **30** and the roller cone **32**, respectively, have non-matching radii. The radius $R_l$ of the circumferential groove **88** in the end face **64** of the leg **30** is smaller than or equal to the radius $R_s$ of the tip **76** of the shirttail portion **36**. The radius $R_c$ of the circumferential groove **90** in the roller cone end face **66** is larger than the radius $R_s$ of the tip **76** of the shirttail portion **36**. The radius $R_c$ of the circumferential groove **90** in the roller cone end face could also be smaller than the radius $R_s$ of the tip **76** of the shirttail portion **36**, as illustrated in FIG. **6B**. The non-matching radii grooves **88** and **90** provide less area for abrasion.

In FIG. **7A**, the end face **66** of the roller cone **32** does not have a circumferential groove. However, a circumferential groove **92** having a radius $R_l$ which is smaller than the radius $R_s$ of the tip **76** of the shirttail portion **36** is provided on the end face **64** of the leg **30**. The smaller-radius circumferential groove **92** on the end face **64** of the leg **30** compensates for wear in the shirttail tip **76**. The circumferential groove **92** may be provided on a non-recessed shirttail, i.e., a shirttail **36** which does not protrude into the roller cone **32**, or on a recessed shirttail (shown in FIG. **7B**), i.e., a shirttail **37** having a tip **39** protruding into a pocket **41** in the end face **64** the roller cone **32**.

Other embodiments of the invention, which do not depart from the spirit of the invention as disclosed herein will be apparent to those skilled in the art to which the invention pertains. Accordingly, the invention shall be limited in scope only by the attached claims.

What is claimed is:

**1**. A roller cone drill bit comprising:

a bit body adapted to be rotated about a longitudinal axis, the bit body having at least one leg depending therefrom, the leg terminating in a shirttail portion, the shirttail portion defining a first end face, the first end face having a first circumferential groove defined thereon, the first circumferential groove having a radius equal to the radius of a tip of the shirttail portion;

a journal cantilevered from the leg; and

a roller cone rotatably mounted on the journal, the roller cone having a second end face adjacent to the first end face and a second circumferential groove defined thereon, wherein the radius of the second circumferential groove is substantially equal to the radius of the tip of the shirttail portion.

2. A roller cone drill bit comprising:

a bit body adapted to be rotated about a longitudinal axis, the bit body having at least one leg depending therefrom, the leg terminating in a shirttail portion, the shirttail portion defining a first end face, the first end face having a first circumferential groove defined thereon;

a journal cantilevered from the leg; and

a roller cone rotatably mounted on the journal, the roller cone having a second end face adjacent to the first end face and a second circumferential groove defined thereon;

wherein the first and the second circumferential grooves have substantially equal radii.

3. The roller cone drill bit of claim 2, further comprising a burn plug disposed in an aperture on the first end face to deflect debris away from the circumferential grooves.

4. The roller cone drill bit of claim 2, wherein a tip of the shirttail portion is received in a pocket in the second end face.

5. The roller cone drill bit of claim 2, wherein the radius of the first circumferential groove is smaller than the radius of a tip of the shirttail portion.

6. The roller cone drill bit of claim 2, wherein the radius of the first circumferential groove is larger than the radius of a tip of the shirttail portion.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 6,533,051 B1
DATED : March 18, 2003
INVENTOR(S) : Amardeep Singh et al.



It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Please replace Figure 3 of the drawings with the attached Figure 3.

Signed and Sealed this

Sixth Day of January, 2004

JAMES E. ROGAN
*Director of the United States Patent and Trademark Office*

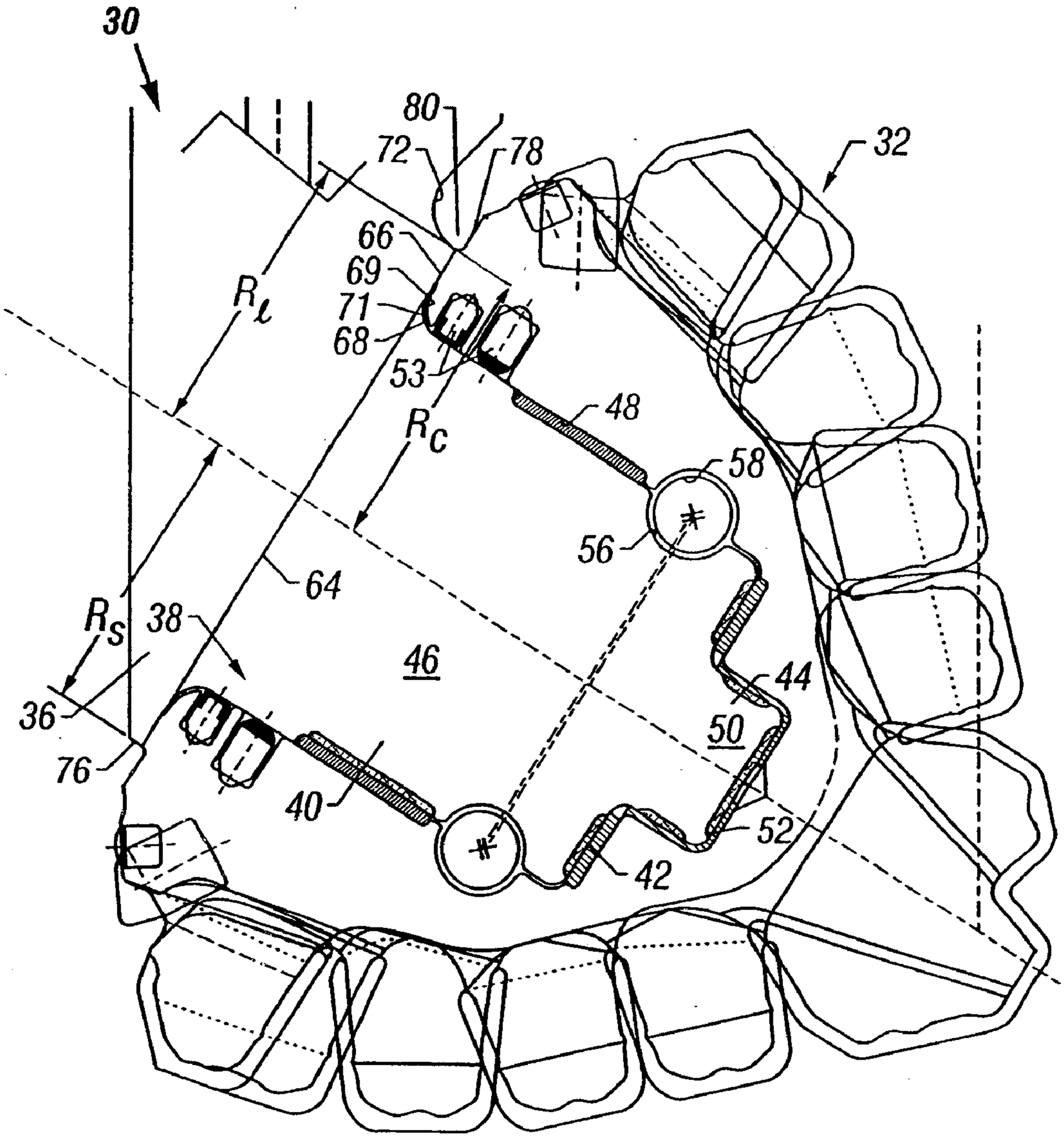



FIG. 3